

**CLAIMS**

Therefore, having thus described the invention, at least the following is claimed:

1. A borosilicate glass, comprising:  
a borosilicate glass composition comprising:  
silicon dioxide ( $\text{SiO}_2$ ) in a range from about 60% to 74% by total composition weight;  
boric oxide ( $\text{B}_2\text{O}_3$ ) in a range from about 9% to 25% by total composition weight;  
aluminum oxide ( $\text{Al}_2\text{O}_3$ ) in a range from about 7% to 17% by total composition weight; and  
at least one alkali oxide in a range from about 2% to 7% by total composition weight,  
wherein the borosilicate glass has a coefficient of thermal expansion (CTE) that is in a range between about  $30 \times 10^{-7}/^\circ\text{C}$  and  $55 \times 10^{-7}/^\circ\text{C}$ , and wherein the borosilicate glass composition resists devitrification upon sintering without the addition of an inhibitor oxide.
2. The borosilicate glass of claim 1, wherein the at least one alkali oxide is selected from lithium oxide ( $\text{Li}_2\text{O}$ ), potassium oxide ( $\text{K}_2\text{O}$ ), and sodium oxide ( $\text{Na}_2\text{O}$ ).
3. The borosilicate glass of claim 1, wherein the borosilicate glass composition further includes:  
zirconium oxide ( $\text{ZrO}_2$ ) in the range between about 0.1% and 5% by total composition weight.
4. The borosilicate glass of claim 1, wherein the borosilicate glass composition further includes:  
at least one alkaline-earth oxide; and  
at least one rare-earth oxide, wherein the sum of the weight percentage is in the range between 0.1% and 7% by total composition weight.

5. The borosilicate glass of claim 4, wherein the alkaline-earth oxide is selected from at least one of barium oxide (BaO), strontium oxide (SrO), calcium oxide (CaO), and magnesium (MgO), and wherein the rare-earth oxide is selected from at least one of lanthanum oxide (La<sub>2</sub>O<sub>3</sub>), tantalum oxide (Ta<sub>2</sub>O<sub>3</sub>), yttrium oxide (Y<sub>2</sub>O<sub>3</sub>) and cerium oxide (CeO<sub>2</sub>).

6. The borosilicate glass of claim 1, wherein the CTE of the borosilicate glass is in a range from about  $30 \times 10^{-7}/^{\circ}\text{C}$  to  $45 \times 10^{-7}/^{\circ}\text{C}$ , wherein the softening point of the borosilicate glass is in a range between about 600 and 1000 °C, wherein the borosilicate glass has a percent weight loss of less than 10 milligrams/dm<sup>2</sup> according to an acid resistance test, wherein the borosilicate glass has a percent weight loss of less than 250 milligrams/dm<sup>2</sup> according to an alkali resistance test, and wherein the borosilicate glass composition comprises:

SiO<sub>2</sub> in the range from about 68% to 73% by total composition weight;

B<sub>2</sub>O<sub>3</sub> in the range from about 13% to 17% by total composition weight;

Al<sub>2</sub>O<sub>3</sub> in the range from about 8% to 15% by total composition weight;

lithium oxide (Li<sub>2</sub>O) in the range from about 2% to 5% by total composition weight; and

zirconium oxide (ZrO<sub>2</sub>) in the range from about 1% to 3% by total composition weight, wherein the sum of the weight percent of SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, and ZrO<sub>2</sub> is less than 78% by total composition weight.

7. A method of making a borosilicate glass, comprising:

forming a homogeneous mixture by mixing a plurality of components, comprising:

silicon dioxide (SiO<sub>2</sub>) in a range from about 60% to 74% by total composition weight,

boric oxide (B<sub>2</sub>O<sub>3</sub>) in a range from about 9% to 25% by total composition weight,

aluminum oxide (Al<sub>2</sub>O<sub>3</sub>) in a range from about 7% to 17% by total composition weight, and

at least one alkali oxide in a range from about 2% to 7% by total composition weight;  
melting the homogeneous mixture; and  
sintering the homogeneous mixture forming a borosilicate glass,  
wherein the borosilicate glass has a coefficient of thermal expansion (CTE) that is in a range between about  $30 \times 10^{-7}/^{\circ}\text{C}$  and  $55 \times 10^{-7}/^{\circ}\text{C}$ , and wherein the homogeneous mixture resists devitrification upon sintering without the addition of an inhibitor oxide.

8. The method of claim 7, wherein forming a homogeneous mixture by mixing a plurality of components further includes:

zirconium oxide ( $\text{ZrO}_2$ ) in the range from about 0.1% to 5% by total composition weight.

9. The method of claim 7, wherein melting the homogeneous mixture further includes:

melting the homogeneous mixture at about  $1650^{\circ}\text{C}$ .

10. The method of claim 7, wherein the CTE of the borosilicate glass is in a range from about  $30 \times 10^{-7}/^{\circ}\text{C}$  to  $45 \times 10^{-7}/^{\circ}\text{C}$ , wherein the softening point of the borosilicate glass is in a range between about 600 and  $1000^{\circ}\text{C}$ , wherein the borosilicate glass has a percent weight loss of less than 10 milligrams/ $\text{dm}^2$  according to an acid resistance test, wherein the borosilicate glass has a percent weight loss of less than 250 milligrams/ $\text{dm}^2$  according to an alkali resistance test; and wherein the homogeneous mixture further includes:

$\text{SiO}_2$  in the range from about 68% to 73% by total composition weight;

$\text{B}_2\text{O}_3$  in the range from about 13% to 17% by total composition weight;

$\text{Al}_2\text{O}_3$  in the range from about 8% to 15% by total composition weight;

lithium oxide ( $\text{Li}_2\text{O}$ ) in the range from about 2% to 5% by total composition weight; and

zirconium oxide ( $\text{ZrO}_2$ ) in the range from about 1% to 3% by total composition weight, wherein the sum of the weight percent of  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ , and  $\text{ZrO}_2$  is less than 78% by total composition weight.

11. The method of claim 7, wherein forming a homogeneous mixture by mixing a plurality of components further includes:

at least one alkaline-earth oxide; and

at least one rare-earth oxide, wherein the sum of the weight percentage is in the range from about 0.1% to 7% by total composition weight.

12. The method of claim 12, wherein the alkaline-earth oxide is selected from barium oxide ( $\text{BaO}$ ), strontium oxide ( $\text{SrO}$ ), calcium oxide ( $\text{CaO}$ ), and magnesium ( $\text{MgO}$ ), and wherein the rare-earth oxide is selected from lanthanum oxide ( $\text{La}_2\text{O}_3$ ), tantalum oxide ( $\text{Ta}_2\text{O}_3$ ), yttrium oxide ( $\text{Y}_2\text{O}_3$ ) and cerium oxide ( $\text{CeO}_2$ ).

13. The method of claim 10, wherein sintering the homogeneous mixture further includes:

sintering the homogeneous mixture at a temperature about  $20^\circ\text{C}$  above the softening point of the homogeneous mixture.

14. A microfluidic device, comprising:

a first assembly comprising a microstructure and a first substrate, wherein the microstructure is disposed on the substrate; and

a second assembly comprising a second substrate and a precursor material, wherein the second assembly and the first assembly are positioned such that the precursor material and the microstructure are adjacent one another, wherein the second assembly is positioned on the microstructure after the first assembly is presintered and adhered thereto by heat treatment to form a one-piece microstructure defining at least one recess between the first and second assemblies, wherein the precursor material includes:

silicon dioxide ( $\text{SiO}_2$ ) in a range from about 60% to 74% by total composition weight;  
boric oxide ( $\text{B}_2\text{O}_3$ ) in a range from about 9% to 25% by total composition weight;  
aluminum oxide ( $\text{Al}_2\text{O}_3$ ) in a range from about 7% to 17% by total composition weight; and  
at least one alkali oxide in a range from about 2% to 7% by total composition weight,

wherein the precursor material has a coefficient of thermal expansion (CTE) that is in a range between about  $30 \times 10^{-7}/^\circ\text{C}$  and  $55 \times 10^{-7}/^\circ\text{C}$ , and wherein the precursor material resists devitrification upon sintering without the addition of an inhibitor oxide.

15. The microfluidic device of claim 14, wherein the precursor material further comprises:

zirconium oxide ( $\text{ZrO}_2$ ) in the range from about 0.1% to 5% by total composition weight.

16. The microfluidic device of claim 14, wherein the CTE of the precursor material is in a range from about  $30 \times 10^{-7}/^\circ\text{C}$  to  $45 \times 10^{-7}/^\circ\text{C}$ , wherein the softening point of the precursor material is in a range from about 600 to 1000  $^\circ\text{C}$ , wherein the precursor material has a percent weight loss of less than 10 milligrams/ $\text{dm}^2$  according to an acid resistance test, wherein the precursor material has a percent weight loss of less than 250 milligrams/ $\text{dm}^2$  according to an alkali resistance test, and wherein the precursor material comprises:

$\text{SiO}_2$  in the range from about 68% to 73% by total composition weight;  
 $\text{B}_2\text{O}_3$  in the range from about 13% to 17% by total composition weight;  
 $\text{Al}_2\text{O}_3$  in the range from about 8% to 15% by total composition weight;  
lithium oxide ( $\text{Li}_2\text{O}$ ) in the range from about 2% to 5% by total composition weight; and  
zirconium oxide ( $\text{ZrO}_2$ ) in the range from about 1% to 3% by total composition weight, wherein the sum of the weight percent of

SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, and ZrO<sub>2</sub> is less than 78% by total composition weight.

17. The microfluidic device of claim 14, wherein the precursor material further comprises:
- at least one alkaline-earth oxide; and
  - at least one rare-earth oxide, wherein the sum of the weight percentage is in the range from 0.1% to 7% by total composition weight.
18. The microfluidic device of claim 17, wherein the alkaline-earth oxide is selected from barium oxide (BaO), strontium oxide (SrO), calcium oxide (CaO), and magnesium (MgO), and wherein the rare-earth oxide is selected from lanthanum oxide (La<sub>2</sub>O<sub>3</sub>), tantalum oxide (Ta<sub>2</sub>O<sub>3</sub>), yttrium oxide (Y<sub>2</sub>O<sub>3</sub>) and cerium oxide (CeO<sub>2</sub>).
19. A method of fabricating a microfluidic device, comprising:
- providing a first assembly comprising a microstructure and a first substrate, wherein the microstructure is disposed on the substrate;
  - providing a second assembly comprising a second substrate and a precursor material wherein the precursor material includes:
    - silicon dioxide (SiO<sub>2</sub>) in a range from about 60% to 74% by total composition weight;
    - boric oxide (B<sub>2</sub>O<sub>3</sub>) in a range from about 9% to 25% by total composition weight;
    - aluminum oxide (Al<sub>2</sub>O<sub>3</sub>) in a range from about 7% to 17% by total composition weight; and
    - at least one alkali oxide in a range from about 2% to 7% by total composition weight,
  - wherein the precursor material has a coefficient of thermal expansion (CTE) that is in a range between about  $30 \times 10^{-7}/^{\circ}\text{C}$  and  $55 \times 10^{-7}/^{\circ}\text{C}$  upon sintering, and
  - wherein the precursor material resists devitrification upon sintering without the addition of an inhibitor oxide;

disposing the first assembly on the second assembly such that the precursor material and the microstructure are adjacent one another; and heating the first assembly and the second assembly to form a one-piece microstructure defining at least one recess between the first and second assemblies.

20. The method of claim 19, wherein providing a second assembly comprising a second substrate and a precursor material wherein the precursor material further comprises:

zirconium oxide ( $\text{ZrO}_2$ ) in the range from about 0.1% to 5% by total composition weight.

21. The method of claim 19, wherein the CTE of the precursor material is in a range from about  $30 \times 10^{-7}/^\circ\text{C}$  to  $45 \times 10^{-7}/^\circ\text{C}$ , wherein the softening point of the precursor material is in a range from about 600 to 1000  $^\circ\text{C}$ , wherein the precursor material has a percent weight loss of less than 10 milligrams/ $\text{dm}^2$  according to an acid resistance test, wherein the precursor material has a percent weight loss of less than 250 milligrams/ $\text{dm}^2$  according to an alkali resistance test, and wherein the precursor material comprises:

$\text{SiO}_2$  in the range from about 68% to 73% by total composition weight;

$\text{B}_2\text{O}_3$  in the range from about 13% to 17% by total composition weight;

$\text{Al}_2\text{O}_3$  in the range from about 8% to 15% by total composition weight;

lithium oxide ( $\text{Li}_2\text{O}$ ) in the range from about 2% to 5% by total composition weight; and

zirconium oxide ( $\text{ZrO}_2$ ) in the range from about 1% and 3% by total composition weight, wherein the sum of the weight percent of  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ , and  $\text{ZrO}_2$  is less than 78% by total composition weight.

22. The method of claim 19, wherein providing a second assembly comprising a second substrate and a precursor material wherein the precursor material further comprises:

at least one alkaline-earth oxide; and

at least one rare-earth oxide, wherein the sum of the weight percentage is in the range from 0.1% to 7% by total composition weight.

23. The method of claim 22, wherein the alkaline-earth oxide is selected from barium oxide (BaO), strontium oxide (SrO), calcium oxide (CaO), and magnesium (MgO); and wherein the rare-earth oxide is selected from lanthanum oxide (La<sub>2</sub>O<sub>3</sub>), tantalum oxide (Ta<sub>2</sub>O<sub>3</sub>), yttrium oxide (Y<sub>2</sub>O<sub>3</sub>) and cerium oxide (CeO<sub>2</sub>).

24. The method of claim 19, wherein heating the first assembly and the second assembly to form a one-piece microstructure defining at least one recess between the first and second assemblies further comprises:

heating the first assembly and the second assembly at about 820 °C for about 5 hours to form a one-piece microstructure.